

**2008  
STATEWIDE COMMERCIAL MUSSEL  
REPORT**



**BY  
Don Hubbs**

**TENNESSEE WILDLIFE RESOURCES AGENCY**  
FISHERIES REPORT 09-07

## TABLE OF CONTENTS

	<u>PAGE</u>
Title Page	i
Table of Contents	ii
List of Figures	iii
List of Tables	iii
List of Appendices	iv
<b>INTRODUCTION</b>	1
<b>METHODS and MATERIALS</b>	3
<b>RESULTS and DISCUSSION</b>	5
<b>SUMMARY</b>	11
<b>RECOMMENDATIONS</b>	12
<b>LITERATURE CITED</b>	13
<b>FIGURES</b>	15
<b>TABLES</b>	22
<b>APPENDICES</b>	35

## LIST OF FIGURES

<u>FIGURE</u>	<u>PAGE</u>
1. Tennessee mussel shell harvest trends, 1998 - 2008	16
2. Tennessee wholesale shell price trends, 1998 - 2008	17
3. Legal sized mussel shell in Kentucky Reservoir population, 1998-2008	18
4. Year class strength of bankclimbers collected from Kentucky Reservoir Section I, N = 60	19
5. Size class strength of bankclimbers collected from Kentucky Reservoir Section I, N = 60	19
6. Zebra mussel collection rate at Kentucky Reservoir commercial mussel assessment sites during August 2006 - 2008	20
7. Annual shell harvest weight distribution by species group (TWRA Receipt Data)	21

## LIST OF TABLES

<u>TABLE</u>	
1. Harvest volume, value, license and shell fee revenue, 1992-2008	23
2. Average wholesale price paid for various categories of commercial shell during 2008	24
3. 2008 wholesale commercial shell harvest by size category, as estimated from Tennessee waters	25
4. Tennessee commercial mussel shell industry volume and value, 2004-2008	26
5. Tennessee's commercial mussel shell harvest size class distribution by weight, 2004-2008	27
6. Summary of commercial mussel species data, Kentucky Reservoir sections I, II, and III	28
7. Kentucky Reservoir percentage legal-sized commercial mussels by category, 2008	32

<u>TABLE</u>	<u>PAGE</u>
8. Cumberland River Old Hickory Reservoir Rome Landing mussel sanctuary, 2008	33

## **LIST OF APPENDICES**

### APPENDIX

I. 2008 Wholesale Mussel Dealer & Receipt Report Summary Data	36
II. Freshwater Mussel Species Collected from Kentucky Reservoir during 2008 Sampling	39
III. Zebra Mussel Distribution in Tennessee	41
IV. Commercial Mussel Program Funding Status	43

## INTRODUCTION

This report contains mussel population and commercial harvest data collected during 2008, and compares recent harvest trends. Activities described in this report were partially funded by the fee on commercial mussels and license sales associated with the commercial mussel program. Any person, firm or corporation who purchases or otherwise obtains freshwater mussels taken from Tennessee waters is required to pay the Tennessee Wildlife Resources Agency (TWRA) the amount equal to \$0.0145 per pound of mussel shells or \$0.0124 per pound of mussel (shell with meat) purchased or obtained. During 2008, TWRA received the following revenues associated with the sale of commercial musseling licenses and collection of the shell fee:

<b><u>TYPE LICENSE</u></b>	<b><u>NUMBER</u></b>	<b><u>REVENUE</u></b>
Resident Commercial Musseling	186	\$ 37, 200
Non-Resident Commercial Musseling	8	\$ 8, 000
Wholesale Mussel Dealer	13	\$ 6, 500
Cultured Pearl	<u>2</u>	<u>\$ 2, 000</u>
<b>Total License -</b>	<b>208</b>	<b>\$ 53, 700</b>
<b>Shell Tax (accrued Jan. 1, to Dec. 15, 2008)</b>		<b><u>\$ 26, 210</u></b>
<b>TOTAL REVENUE</b>		<b><u>\$ 79, 910</u></b>

Adequate funding has been a problem for the commercial mussel program for more than a decade due to declining license sales. TWRA has experienced a drastic decline in the number of harvester licenses sold since the fee was levied (down from average of 1,440/year during 1990-95 to 258/year for last 5 years). Costs of annual harvester's licenses increased from \$125 to \$200 for residents and from \$250 to \$1,000 for non-residents in 2006, yet license revenue remains inadequate to fund the program. The current shell fee paid to TWRA by wholesale mussel dealers has not increased since it was levied in July 1991. While it was originally intended to provide a mechanism for tracking annual shell harvests, increasing the fee has now become the logical method to fund the program. In order to balance the commercial mussel program's funding deficit, TWRA's Commercial Mussel strategic plans have recommended an increase in the shell fee for more than 10 years.

During the last century, the harvest of mussel shell has fluctuated according to market demand. Mussels were first harvested for the natural pearls they can produce, then as a source of raw material for buttons and mother of pearl inlay, and finally for the production of cultured pearl nuclei. The majority of freshwater mussel shells harvested in Tennessee were shipped to Japan, China and other countries where they were cut and polished into beads. These beads were inserted into marine oysters and freshwater mussels to form cultured pearls. According to Olson (2007), Tennessee continues to lead the United States in pearl and mother of pearl shell production. Tennessee's commercial mussel shell industry accounted for 71% of the total shell harvest value and 21% of the total value of all natural gemstones produced in the United States during 2006 (latest figures available from USGS).

Through the early 1990's, commercial musseling employed as many as 3,000 people in Tennessee. However, biological problems affecting the survival and production of Japan's pearl producing oysters combined with other factors affecting the cultured pearl industry, Japanese and U.S. economies, reduced the market for Tennessee's mussel shells beginning in 1997. Some shell exporters chose to ship only their highest quality shells during this period creating a narrower market with a lower demand for the standard quality shells, this contributed to lower domestic wholesale shell prices. The decreased demand and lower wholesale prices caused a substantial decline in the number of mussel harvesters working in Tennessee. By 2004, Tennessee's shellfishery had stabilized at a lower level where on average, less than 300 harvesters take less than 1,500 tons per year.

Estimated value of pearl production by market share was, White South Sea cultured pearls (Australia, Indonesia, the Philippines, Myanmar) 35% US\$ 220 million, Freshwater cultured pearls (China) 24% US\$ 150 million, Akoya cultured pearls (Japan, China) 22% US\$ 135 million, Tahitian cultured pearls (French Polynesia) 19% US\$ 120 million, total estimated pearl production US\$ 625 million (PEARL OYSTER 2006). China has rapidly grown its cultured pearl industry and is now the largest producer of cultured pearls, producing 95% of the cultured pearls as of 2008 (PEARL OYSTER 2008). Since 2004, China has increased its use of shell bead pearl nuclei resulting in US wholesale shell price increases. The Hong Kong Pearl Association (HKPA), a trade group composed of cultured pearl dealers, some of whom are also pearl farmers, estimates that China grew 1,654 tons of freshwater cultured pearls in 2006. Of that volume, an estimated 882 tons were suitable for use in jewelry. That jewelry-use tonnage is nearly 13 times the volume generated by all the other pearl-producing countries combined (Loupe Online 2008). Each rise and fall in cultured pearl demand has affected the quantity and quality of the mussel shell resource available for harvest and export.

Tennessee's quality commercial mussel stocks were primarily limited to Kentucky Reservoir (Hubbs 2008a). Kentucky Reservoir stretched 184.3 miles from Pickwick Dam at Tennessee River mile (TRM) 206.7 in Hardin County, TN to Kentucky Dam at TRM 22.4 near Gilbertsville, Kentucky. The Tennessee portion contained 1,971 shoreline miles and approximately 110,990 surface acres, ending at TRM 49.2 in Stewart County, TN. The main channel and over-bank widths varied from 0.25 to 2 miles. Information gathered from wholesale mussel dealers showed that most of the annual harvest was reported from Kentucky Reservoir. No other Tennessee waters appeared to contain mussel populations of sufficient quality, size and diversity to sustain a continuous commercial harvest.

Some wholesale mussel dealers have complained about the lower quality of shells being harvested from the mud and clay bars in the northern half of Kentucky Reservoir and the increase in "snout nosed mapleleaves" (*Quadrula apiculata*). They described the shells as having a "river grade" appearance, indicating that the periostracum in the umbonal area of the shell was damaged or missing, and the shells had a generally rougher exterior. The increased abundance of lower quality shells from this region could be attributed to the accumulation of Asian clam (*Corbicula fluminea*) shell shards, which now compose the top substrate layer on many of the clay bars where mussels are harvested (personal observation). The periostracum of mussels growing in these shell shards is worn away as the mussel moves through the substrate exposing the shell to degradation through dissolution, erosion, and staining.

No mussel die-offs were reported from Kentucky Reservoir during 2008. Tennessee Valley Authority increased the frequency of generation cycles at Pickwick Dam during summer to improve water quality and reduce occurrence of no flow through the reservoir. Drought conditions increased the acreage of aquatic vegetation growing in the reservoir, coontail and southern naiad dominated vegetation identified in Kentucky Reservoir, while hydrilla sp. was identified in the middle portion of the reservoir (Broadbent 2008).

Old Hickory Reservoir was also sampled during 2008 to ascertain the status of its mussel resources in relation to altered flows and water temperatures resulting from maintenance operations at Wolf Creek Dam and to collect mussels for a translocation project funded by the National Park Service. The reservoir is located on the Cumberland River between Carthage and Nashville, running 97.3 river miles between Cordell Hull Dam (CRM 313.5), Smith County, TN and Old Hickory Dam (CRM 216.2), Davidson County, TN. Substrate ranged from silt to sand, gravel, cobble, and bedrock. Recently, this reservoir has not produced significant quantities of commercial mussel shells due to inconsistency of shell quality and reduced recruitment due to prolonged exposure to cold hypolimnetic releases from upstream reservoirs. Survey efforts were concentrated in the Rome Ferry sanctuary (CRM 292.5 to CRM 313.5) where historically mussel densities had been high.

During 2008, commercial musselers were restricted to harvesting only those individuals of the 10 freshwater mussel species listed below. Only individuals that will not pass through a ring with an inside diameter specified for that species as legal in Tennessee may be harvested. All other mussels were required to be returned immediately and unharmed to the bed from which they were taken.

<u>Mussel Species Listed for Harvest</u>	<u>Inside Ring Diameter in inches</u>
Pink heelsplitter ( <i>Potamilus alatus</i> )	4.0
Washboard ( <i>Megaloniais nervosa</i> )	4.0
River pigtoe ( <i>Pleurobema cordatum</i> )	2 5/8
Lake pigtoe ( <i>Fusconaia flava</i> )	2 5/8
Mapleleaf ( <i>Quadrula quadrula</i> )	2 5/8
Snoot nose Mapleleaf ( <i>Quadrula apiculata</i> )	2 5/8
Three ridge ( <i>Amblema plicata</i> )	2 5/8
Elephant Ear ( <i>Elliptio crassidens</i> )	2 5/8
Monkeyface ( <i>Quadrula metanevra</i> )	2 3/8
Ebony ( <i>Fusconaia ebena</i> )	2 3/8

## **METHODS and MATERIALS**

The wholesale value of the mussel harvest was calculated by surveying active commercial mussel dealers' monthly records, and reviewing TWRA mussel receipts to collect price data for each shell category. Wholesale mussel receipt reports provided by TWRA's Data Management Division were used to calculate the total commercial harvest volume, species distribution and percent size composition (Clouse 2009). In 2008, the commercial mussel shell category known

as "lake mix" was composed of the following species: threeridge (*Amblema plicata*), snootnose mapleleaf (*Q. apiculata*), mapleleaf (*Q. quadrula*), and lake pigtoe (*Fusconaia flava*).

Multiplying the average annual price per pound by the estimated number of pounds harvested and then summing the categories derived the annual harvest value.

Commercial mussel population assessments were conducted on Kentucky Reservoir because it contains the most important commercial mussel beds. Major collection efforts were directed toward sampling areas frequented by commercial harvesters. Because mussels exist as clumped, contiguous aggregations, stratified sampling techniques were employed. The reservoir was divided into three sections based on major hydrological characteristics. Specific sample locations were selected based on presence of significant mussel resources (density, diversity, and harvest activity).

Sampling on the Cumberland River - Old Hickory Reservoir during 2008 was concentrated around two locations in the Rome Ferry Landing sanctuary. Each collection site was characterized according to location, substrate composition, water depth and any other relevant characteristics. The specific location of each site was recorded by river mile, proximity (left, right descending side or center), and latitude and longitude (determined by a global position system). To aid data interpretation, population metrics were calculated with individual samples pooled for all collection methods and presented for each location.

Vessel to diver communications (Ocean Technology Systems) and surface supplied air compressor (Hookah system) were the preferred dive method used to conduct surveys and collect samples in deep water environments (reservoirs and mainstream rivers). Before sampling a given area, side-scanning sonar (Hummingbird model 987c SI) was used to analyze bottom characteristics and detect underwater obstructions that might impair collection efforts. In shallow water where samples could be collected by snorkeling or hand picking the aerial extent of the mussel bed (shoal) was visually determined before a representative sample was collected from the bed. Species composition was determined from timed collections. Effort was directed toward the collection of commercial mussel species consistent with methods employed by commercial mussel harvesters utilizing surface-supplied air diving equipment. On Kentucky Reservoir, each commercial assessment site consisted of ten tethered dives with five minutes of active collecting per sample replicate. While not as quantitative as measured area sampling (i.e. quadrats), CPUE usually detects greater numbers of mussels and species richness especially in situations where mussels occur in low abundance (Strayer and Smith 2003). Because a larger sample size could be attained during timed collections, this was the preferred method. However, on other reservoirs where low site density, depth, or swift current rendered this method impractical; timed dives of varied duration were employed to generate catch per unit effort data (CPUE).

All mussels collected were placed in mesh bags, brought to the surface for examination, and either retained for additional analyses or returned to the bed after enumeration. Mussels collected during population surveys were identified to species, enumerated, and recorded. Commercial species were measured (using rings of 2 3/8, 2 5/8 and 4.0 inches inside diameter according to current size limits for each species) to determine size distribution. Data were entered into a computer spreadsheet to tabulate species composition, size distribution, and relative abundance parameters. The legal-sized portion of the population was determined for all



commercial species.

## **RESULTS and DISCUSSION**

### **Commercial Shell Market Assessment**

The shell industry in Tennessee has harvested 28,267 tons (56,533,680 lb) of mussels with an estimated wholesale value of \$63,030,694 since 1992 (Table 1). The export value of this harvest is estimated to range \$189,092,080 to \$315,153,470 (three to five times the wholesale value). During the same period, TWRA received \$2,216,895 in revenue (\$1,483,840 from license sales and \$733,055 from the fee on mussel shells) only 3.52 % of the wholesale value of the resource. These figures indicate sufficient value exists in the commercial shell industry to provide improved funding for its management.

While the shellfishery volume has declined since the 1990's, more recently shell prices had increased (average up \$0.42/lb during 2003-07), and recent annual harvests were averaging 2.8 million pounds per year before the global recession slowed demand in the third quarter of 2008. Increasing the shell fee is the most practical way to fund the management of this unique resource. Given current harvest and license trends, the shell fee should be set at \$0.10 /lb (yield ~\$280,000/year) to balance the current program cost of ~\$275,000/year and recoup past funding deficits.

During the late 1980's through 1995, intense harvest pressure on Kentucky Reservoir's mussel stocks resulted in mussels being taken almost immediately after attaining legal size. TWRA's concern for declining percentages in the adult portion of mussel populations led to recommendations to increase the legal size limit on washboards from 3  $\frac{3}{4}$ " to 4", and increasing the size limit on lake mix shells from 2  $\frac{5}{8}$ " to 2  $\frac{3}{4}$ ". In April 1999, the Tennessee Wildlife Resources Commission voted to increase the size limit on washboards from 3  $\frac{3}{4}$ " to 4", staggering the increase in 1/16" increments over a four-year period beginning in 2000 and ending in 2003 when the size limit reached 4". The size limit on lake mix shells remains at 2  $\frac{5}{8}$ ", however reduced demand and lower harvest pressure has allowed some expansion of the 2  $\frac{3}{4}$ " size class.

Tennessee's freshwater mussel shell market volume decreased significantly during 2008 (Figure 1), however higher prices were paid for 2  $\frac{3}{4}$ " ebony and 4" washboards (Figure 2). Monthly price data obtained from wholesale mussel dealers and TWRA mussel receipts were tabulated to compute average price paid for the major categories of shell. After harvest, shells are normally sized and grouped into the categories listed in Table 2. Shell values were only reported for green (live mussels), because the wholesale market for open (dead) mussel shell was very limited.

Information from TWRA's wholesale mussel receipt system, wholesale mussel dealer summaries, in addition to the wholesale price survey were used to compute the volume and value of the reported mussel harvest (Table 3). Tennessee wholesale mussel dealers reported purchasing 1,583,626 pounds (792 tons) of mussels from Tennessee waters during 2008. The harvest value was estimated at \$1,387,187 compared to \$2,378,398 paid for 2,505,205 pounds (1,253 tons) in 2007. Higher average prices were paid for most categories until August, then prices dropped by 50% before buyers shut down completely by mid October substantially

reducing the harvest volume and value. Market decline resulted in fewer harvesters, the number of licensed harvesters increased from 334 in 2007 to 194 in 2008 (Table 4). The average income per harvester remained similar at \$7,150 compared to 2007 level of \$7,121 due to the decreased number of licenses sold (Figure 1).

The average price of 2 3/8" ebony shells continued to decline from a high of \$0.61 in 2006 to \$0.48 in 2007 and \$0.36/lb by 2008. While decreased demand for smaller sized shells drove prices down, the 2 5/8" ebony increased \$0.11 from \$0.88 to \$0.99, and the 2 3/4" increased \$0.05 from \$1.00/lb to \$1.05/lb. Both the 2 5/8" and 2 3/4" lake mix shells remained \$1.25/lb for most of the year however, when prices dropped to \$0.85/lb in August the average was reduced to \$1.20/lb for the year (Figure 2). Minimum sized 4.0" lake washboard (*Megaloniaias nervosa*) prices increased \$0.08 to \$1.36/lb.

The lower priced 2 3/8" and 2 1/2" (ebony and monkey-face *Q. metanevra*) categories combined, comprised 23% of the harvest weight but only 9.5% of the total value. Ebony shell in the 2 5/8" to 2 3/4" size comprised 16% by weight and 18% by value of the 2008 harvest. All size categories combined, the ebony shell produced 48% by weight and 32% by value of the harvest. Landings of lake mix categories (2 5/8" and 2 3/4") declined by 7% from 47% by weight in 2007 to 40% in 2008 and the total value dropped from 62% to 55% (Table 2). Lake grade washboards 4.0" and larger increased 2% from 5.02% to 7.05% by weight and 4% by value from 6.77% to 10.95%. River grade washboard production remained low at 502 pounds. The market for colored shells (pinks), increased lead by elephantear (*Elliptio crassidens*), producing 4.92% by weight (Figure 7) and 2.81% by value. These shifts in species and sizes of commercial shell landings were attributed to a general economic decline and in market fluctuations. Weighted average wholesale price paid to harvesters declined (from \$0.95/ lb in 2007 to \$0.88 in 2008), reversing a steady increase during the previous five years (Table 4).

According to wholesale dealer receipts, 95.09% of the 2008 Tennessee mussel harvest came from Kentucky Reservoir (Appendix I). An analysis of Kentucky Reservoir's harvest data and size distribution by species group showed 58% by weight of the ebony shells were between 2 3/8" and 2 1/2", compared to 41% at 2 5/8" and larger. Increased harvest pressure on the lake mix group reduced the weight of 2 3/4" shells (from 37% in 2007) to 30%, with the 2 5/8" increasing (from 63%) to 70%. Lake grade washboards accounted for 7.4% of the Kentucky Reservoir harvest weight, and were almost entirely made up of 4.0" grade shells with only three pounds reported as  $\geq 5.0$ ". The majority of the elephantear harvest (89%) came from Fort Loudon Reservoir. No harvest of mussel shells imported from other states was reported.

Because of their longevity and relatively slow growth, commercial mussel populations subjected to intense harvest pressure are susceptible to being "cropped off" (very low percentage of legal-sized and larger individuals present in a population) (Figure 3). When this occurs, the shell industry has to fill orders with higher percentages of the more abundant, smaller categories of mussel shell. Conversely, when harvest pressure is reduced, viable commercial mussel populations recoup allowing increased recruitment into the larger size classes. Variation in the size distribution of the shells harvested can also be attributed to shifts in demand for different shell products. This is evident when comparing the distribution of the percent weight by size category data during 2004 to 2008. During this period, the combined percent weight of the 2 3/8" and 2 1/2" categories fluctuated from 42% to 32%. The shell industry has experienced

difficulty meeting the market demand for the 2 ¾" lake mix (down to 13.9% in 2008) and legal sized washboard shells ( $\geq 4"$ ) which remained  $\leq 7\%$  of the total harvest weight (Table 5). The worldwide economic decline that commenced in the third quarter of 2008 will certainly have a negative effect on the commercial shell industry as consumers reduce their expenditures on luxury items like cultured pearls. However, with a reduced shell industry, Kentucky Reservoir's mussel populations will be afforded additional time to grow into larger size classes that should return increased value and future marketability.

### **Mussel Population Assessments**

The Tennessee portion of Kentucky Reservoir was sampled at fifteen commercial mussel sites (eleven open water sites and four closed harvest sites in the mussel management area and in two sanctuaries) during 2008. One hundred ten five-minute timed dive grab samples were taken from open harvest waters and 40 from closed harvest waters: for a total of 750 minutes of collection effort netting 5,547 mussels. Thirty-four freshwater mussel (Unionid) taxa were recorded, during all 2008 survey activities on Kentucky Reservoir along with two exotic bivalve species (Asian clam, *Corbicula fluminea* and zebra mussel, *Dreissena polymorpha*) (Appendix II).

**Section I** – Tennessee River Mile 49.2 to 82.5. Paris Landing/White Oak Creek. This section is dominated by reservoir over-bank habitat with silt, sand, Asian clam shells, and clay substrates, with gravel along the shorelines. During years of high commercial shell demand, mussel harvest pressure has reached ten harvesters per river mile. Harvest pressure is spread across the shallow (<10 - 15 ft) bars, shoreline habitats, old creek channels and river channel wall (depth >20 - 50 ft). Commercially valuable mussel species are found amongst the clay and gravel bars, scattered in the bays, along shorelines, and more concentrated near and along sloping channel walls. Densities rarely exceed ten mussels per square meter away from the main channel. Mussel recruitment is primarily limited to areas with well-established mussel populations. Mussels in this section of the lake exhibit the fastest shell growth rate, but overall densities are low. Few recent records of endangered mussel species are known from this section.

Four sites were sampled during 2008, producing 936 individuals representing nine of the ten commercial mussel species (Table 6). The five most abundant species are all commercially important; the threeridge (*A. plicata*) 34%, ebony shell (*F. ebena*) 32%, mapleleaf 14% (*Q. quadrula* and *Q. apiculata* combined), and washboard (*M. nervosa*) 11%. Approximately 37% of the commercial species collected were legal-size or larger, up from 31% in 2007. Timed sampling resulted in an average collection rate of 4.38 mussels per minute down from 7.40 in 2007.

One new site was sampled targeting the bankclimber (*Plectomerus dombeyanus*), a shell with purple nacre, which has invaded the reservoir and may eventually warrant addition to the list of commercially harvested species. Sixty individuals were collected at a CPUE of 18 per hour from all four sites combined. Age and size class strength data are presented in Figures 4 and 5. The data suggest that ten or more years of population growth may be required before sufficient numbers of three inch or larger bankclimbers are available for harvest. The zebra mussel collection rate decreased dramatically from 1.6 per minute (240 individuals) in 2007 to 0.02 per minute (three individuals) in 2008 (Figure 6). The Asian clam was abundant at all sites, with

their dead shells comprising a majority of the top layer of substrate.

**Section II** - TRM 82.5 to 111.1. Harmons Creek/New Johnsonville/Duck River. This section is a transitional area with both lotic and lentic habitats. Mussel harvest pressure has reached ten harvesters per river mile. Harvest pressure is dispersed over the bays, submerged creek channels, over-bank bars, channel walls and old riverbed at depths from one to > 50 ft. Mussel populations are dispersed throughout the varied habitats, and reach maximum densities (> 100 mussels per square meter) in the river channel. Population recruitment is high in and near the main river and creek channels resulting in colonies expanding from these habitats. Substrate composition varies from silt, sand, clay, to gravel, Asian clam shells, cobble, and bedrock. Several recent endangered mussel species records (pink mucket, *Lampsilis abrupta*) exist for this section (Parmalee and Bogan 1998).

Six sites were sampled during 2008; four in waters open to commercial harvest and two from closed waters. Eight of the ten commercial mussel species were collected from the open water sites totaling 1590 individuals. The collection rate was 7.95 mussels per minute up from 6.41 in 2007. The closed harvest sites yielded nine of ten commercial species totaling 717 individuals with a CPUE of 7.17 down from 9.02 in 2007 (Table 6). Two commercially important species composed 75% of the open water population (threeridge 9%, and ebony 66%), followed by washboard 12%, and mapleleafs (5%). Lower harvest pressure on the ebony shell contributed to an increase in the legal-sized portion from 10% in 2007 to 40% in 2008. Washboards collected were 10% legal-sized and comprised 12% of the sample from open waters compared to 50% legal-sized but only 3% abundance from closed waters. Approximately 34% of all commercial species collected from open waters were legal-sized or larger compared to 15% in 2007, and 48% from the closed water sites. The zebra mussel collection rate decreased dramatically from 0.6 per minute (92 individuals) in 2007 to 0.02 per minute (three individuals) in 2008 (Figure 6). The Asian clam was abundant at all sites, with their dead shells comprising a portion of the top layer of substrate.

**Section III** - TRM 111.1 to 206.7. Located south of the mouth of the Duck River to Pickwick Dam. Lotic habitats dominate this section. Harvest pressure averages less than one harvester per river mile. However, harvest pressure can be intense around the shallow (10 - 25 ft deep) sand/gravel bars and around mainstream islands. Some harvest also occurs in the larger bays of this reach. Mussel populations are primarily found outside the navigation channel when depths are less than 40 feet, in and near the old river channel, and along the shorelines. Maximum densities (> 100 mussels per square meter) and recruitment levels are found outside the navigation channel in the shallow gravel deposits on the inside river bends and at the head and tail areas of mainstream islands. Many recent endangered mussel records for several different species exist for this section (Hubbs 2008).

Five commercial mussel population assessments were performed in this section during 2008, three in open harvest waters below Diamond Island (TRM 195), along the head of Swallow Bluff Island (~TRM 170.3), and one in the back shoot of Eagle Nest Island (~TRM 164.0). Two sanctuaries were sampled, one located at Cedar Creek (TRM 141.5), and the other below Pickwick Dam (TRM 203). A fine brown particulate released from Packaging Corporation of America's Counce diffuser outfall located at TRM205.5 obstructed visibility in the water column

during sampling conducted on August 4, 2008 as far downstream as Chalk Bluff (TRM 185). Nine of the 10 commercial mussel species and 14 federal endangered pink muckets (*L. abrupta*) were collected totaling 1,284 individuals from the three open water sites. A layer of young of the year Asian clams (length ~ 5mm) covered the bottom at TRM 195. The collection rate was 8.47 up from 6.89 mussels per minute in 2007, but only 10% were legal size or larger compared to 13% previously. Young ebony shell mussels dominated the sample population (77% only 8% legal), followed by monkeyface (12 %) and elephantear (*E. crassidens*) (7%). The Asian clam was abundant at all sites, with their dead shells comprising a portion of the top layer of substrate. Eighteen zebra mussels were encountered, during 250 minutes of sampling at the same rate as in 2007 (0.07 per minute).

**Section I, II, & III combined** - Reservoir wide sampling of open waters resulted in the collection of 3,743 mussels representing the ten commercial taxa at an average collection rate of 6.8 mussels per minute, similar to the 6.9 collected in 2007. Twenty-seven percent of the commercial mussels collected were legal sized or larger up from 21% in 2007. It was noted that legal sized washboards increased from one percent in 2007(5 of 344) to six percent (18 of 297) in 2008. While improved, the continued low percentage of legal sized washboards was attributed to the impact of harvest pressure and previous years (2001 to 2004) illegal harvest and sale of sub-legal sized washboards documented by TWRA and USFWS law enforcement investigations (F. Couch, personal communication). Commercial harvest of Tennessee's mussel shells did not exceeded 2,000 tons during 2004 to 2008., and lower overall demand has allowed mussel populations to recover somewhat from more than a decade of intense harvest activity. However, the previous five years of harvest pressure above 1,200 tons per year and high recruitment of young mussels into the population caused an overall decrease in the percentage of legal-sized mussels in Kentucky Reservoir since 2006 (Figure 3).

The ebony shell is the foundation species of Tennessee's commercial shell market. On average, the ebony shell comprised 53% by weight and 42% by value of the harvest during the last five years (Figure 7). Under the continuous harvest pressure, the legal-sized population has decreased from 61% in 2005 to 29% in 2008. The legal-sized washboard population has remained very low during the last five years. It averaged 3% legal-sized shells during 2004-08, while averaging 6% by weight and 7% by value of the harvest. The 1/16" per year (2000 to 2003) incremental size limit increase, and illegal harvest of smaller than 4.0" washboards during 2001 to 2004, are considered contributing factors to its decline in the harvest. The lake mix group (threeedge, mapleleaf, and pigtoe) with legal sizes averaging 28%, up from 26% in 2007, has not been as sensitive to harvest pressure as the washboard. During the last five years, the lake mix group averaged 38% by weight and 47% by value of Tennessee's commercial shell market. However, it has fluctuated between 15% to 28% legal-sized during 2004 to 2008. The inverse relationship between the tons of shell harvested and the percent legal-sized remaining, suggests the washboard population remains overharvested while the ebony and lake mix groups are also affected by sustained moderate harvest pressure (Table 7). Because abundance of the adult portion of the population is negatively correlated with harvest pressure, some populations (washboard and lake mix) remain below the markets demand and the reservoir's carrying capacity. Current size limits appear adequate to protect reproduction; however, previous year's harvests may affect recruitment into the fishery.

Zebra mussels were encountered in notably fewer numbers than in 2007, which had shown a marked increase compared to previous years. Only 21 individuals were collected during 750 minutes of sampling at the 15 commercial sites compared to the 339 individuals collected during 400 minutes of sampling during 2007. The reservoir wide collection rate dropped from 0.8 to 0.03 per minute which was also less than the 27 individuals collected during 2006 (collection rate = 0.08 per minute).

**Cumberland River - Old Hickory Reservoir** – Survey efforts focused on two locations in the Rome Ferry sanctuary (CRM 292.5 to CRM 313.5) where mussel densities had historically been high. Sampling trips were made during June, August, and October, depth at sample locations ranged 15 to 30 feet, visibility reported by divers was less than three feet, water temperatures ranged 72 to 55 °F and flows ranged ~1,500 to 3,800 cubic feet per second (cfs) respectively (<http://lakeinfo.tva.gov/>).

The reach (CRM 299.5 to 297.5) around Lovell's Island (CRM298) was sampled at nine sites for 6.8 person-hours. Two hundred eighty-five live mussels representing nineteen species were collected resulting in a CPUE of 0.7 mussels per minute. Divers spent 15 to 20 minutes per site attempting to locate mussels with varied success; three sites between CRM 299.5 to 299.0 near a bluff along the left descending side produced few live mussels. The majority of the mussels collected from this reach were taken during six dives of up to 60 minutes duration, in the back chute of Lovell's Island (Table 8). Some of the sites examined had been covered with three to six inches of silt while the more productive ones had predominately sand and gravel substrate with less silt. The monkeyface, washboard and river pigtoe (*P. cordatum*) were the most abundant species collected (25, 23 and 21% respectively). Ninety-six percent of the monkeyface, 88% of washboards and 85% of the river pigtoes were legal-sized indicating the older age structure of the population. Two federally endangered species were collected, the pink mucket (23 individuals) and two rough pigtoes (*P. plenum*).

The reach (CRM 305 to 305.5) around Carter's Island was sampled at six sites for 3.3 person-hours. One hundred twenty-five live mussels representing ten species were collected resulting in a CPUE of 0.63 mussels per minute. The majority of the mussels collected from this reach were taken during four dives of up to 60 minutes duration, in the back chute of Carter's Island (Table 8). Mussels were located in silt-covered sand and gravel in and around submerged trees along the left descending side and in gravel-filled crevices in the bedrock bottom. Washboards dominated the sample composing 70% of the total of which 95% were legal-sized, followed by pimpleback (*Q. pustulosa*) and pink mucket at 6%.

No zebra mussels were encountered during 10.1 person-hours of sampling effort at all sites, the Asian clam was encountered in low to moderate densities. Gravid individuals of several species were noted, tacytic species released glochidia in packets, and some of the bradytic species (pink mucket and black sandshell *Ligumia recta*) exhibited mantle displays. Relic shells of washboard and pigtoes were abundant in depositional areas of the riverbed. Mussel recruitment in this reach of the Cumberland River has long been suppressed by cold water resulting from the hypolimnetic releases from upstream reservoirs (Wolf Creek, Dale Hollow, and Center Hill). However, warmer water temperatures observed during the two most recent summers (2007 and 2008) due to flow alterations caused by renovations at Wolf Creek Dam has caused some species to become gravid and active spawning displays of others. Evidence of

recruitment within the last ten to fifteen years was noted for the following species *Q. pustulosa*, *Q. metanevra*, *L. abrupta*, *Lasmigonia complanata*, *L. fragilis*, while the rest were represented by older specimens that continue to decline in abundance.

## SUMMARY

Work performed under TWRA Commercial Musseling project number 7363 addressed Strategic Plan Problem I. Strategies 1, 2 and 3. License sales and mussel fee revenue associated with the commercial mussel program garnered \$105,710 during 2008. Tennessee's mussel shell market declined due to a global recession during 2008. Tennessee wholesale mussel dealers reported purchasing 1,583,626 pounds (792 tons) of mussels from Tennessee waters during 2008. The harvest value was estimated at \$1,387,187 compared to \$2,378,398 paid for 2,505,205 pounds (1,253 tons) in 2007. Higher average prices were paid for most categories until August, then prices dropped by 50% before buyers shut down completely by mid October substantially reducing the harvest volume and value. Market decline resulted in fewer harvesters, the number of licensed harvesters decreased from 334 in 2007 to 194 in 2008.

Decreased demand for smaller sized shells drove the average price of 2 3/8" ebony shells down from a high of \$0.61 in 2006 to \$0.48 in 2007 and \$0.36/lb by 2008. While decreased demand for smaller sized shells drove prices down, the 2 5/8" ebony increased \$0.11 from \$0.88 to \$0.99, and the 2 3/4" increased \$0.05 from \$1.00/lb to \$1.05/lb. Both the 2 5/8" and 2 3/4" lake mix shells remained \$1.25/lb for most of the year however, when prices dropped to \$0.85/lb in August the average was reduced to \$1.20/lb for the year (Figure 2). Minimum sized 4.0" lake washboard prices increased \$0.08 to \$1.36/lb. The market for colored shells (pinks), increased lead by elephantear. These shifts in species and sizes of commercial shell landings were attributed to a general economic decline and in market fluctuations. Weighted average wholesale price paid to harvesters declined (from \$0.95/ lb in 2007 to \$0.88 in 2008), reversing a steady increase during the previous five years.

According to wholesale dealer receipts, 95.09% of the 2008 Tennessee mussel harvest came from Kentucky Reservoir. An analysis of Kentucky Reservoir's harvest data and size distribution by species group showed 58% by weight of the ebony shells were between 2 3/8" and 2 1/2", compared to 41% at 2 5/8" and larger. Increased harvest pressure on the lake mix group reduced the weight of 2 3/4" shells (from 37% in 2007) to 30%, with the 2 5/8" increasing (from 63%) to 70%. Lake grade washboards accounted for 7.4% of the Kentucky Reservoir harvest weight, and were almost entirely made up of 4.0" grade shells with only three pounds reported as  $\geq 5.0$ ". The majority of the elephantear harvest (89%) came from Fort Loudon Reservoir. No harvest of mussel shells imported from other states was reported.

The Strategic Plan objective of increasing/maintaining commercial mussel populations to a level where  $\geq 15\%$  are above legal-size limits was met for the ebony and lake mix categories.

Although, sustained harvest pressure caused a decline in the legal-sized ebony shell population (29% in 2008) compared to the five-year average (41%), while the legal-sized lake mix population increased (28% in 2008 compared to five-year average of 23%). Kentucky Lake washboards failed to reach the objective, however they did improve to 6.0% above legal-size compared to the five-year average of 3%. Strategic Plan Problem VII. Strategy 2 dealing with the

introduced aquatic nuisance species *Dreissena polymorpha* (zebra mussel) was partially accomplished in Appendix III, via information exchange with the U.S. Army Corps of Engineers and Tennessee Valley Authority. Lack of funding restricted monitoring efforts to only those that coincided with scheduled freshwater mussel investigations.

Even during periods of decreased harvest activity, law enforcement continues to play a critical role in the management and protection of Tennessee's valuable mussel resources. History of the commercial shell industry's buying practices indicates that market demand for a particular category of shell can trump any regulation against the harvesting of said shell. The viability of the commercial mussel populations can be assured only through adherence to adequate minimum size regulations and maintaining the integrity of closed waters for population comparisons and species protection. Minimum shell size regulations are based on conservative age and growth estimates, which allow brooding female mussels several years to spawn before reaching the species-specific legally harvestable size limit.

### **RECOMMENDATIONS**

The commercial mussel program continues to be inadequately funded. In order to monitor and protect this valuable renewable resource, many person-hours of biological and law enforcement effort are required to guard against illegal take, overexploitation, and habitat degradation. Therefore, in order for this program to meet its fiduciary and resource management responsibilities, the following recommendations are offered:

1. Seek increased revenue to fund fully the existing commercial mussel program (Appendix IV). The current shell fee paid to TWRA by wholesale dealers has not increased since it was levied in July 1991 at \$0.0124/lb for live mussels (shell with meat) and \$0.0145/lb for open shells (shells without meat). In order to balance the commercial mussel program's deficit, TWRA's Commercial Mussel strategic plans have recommended an increase in the shell fee for more than 10 years. TWRA has experienced a drastic decline in the number of harvester licenses sold since the fee was levied (down from average of 1,440/year during 1990-95 to 258/year for last 5 years). The fee on commercial mussels and shells should be increased to a level sufficient to fund the commercial mussel program (approximately \$0.10 per pound at the current five-year average harvest level).
2. Extend the Cedar Creek Sanctuary to include Kelly's Island and Tennessee River Mile 145.0. Combined brail and dive samples indicate that the majority of the mussel stocks in this reach lie within a bed that extends from TRM 145 - 141.0. This extension would protect a population of the rare spectaclecase mussel (*Cumberlandia monodonta*) (Garner, 1991) and better protect the existing mussel bed. By making this addition to the sanctuary system, not only would rare and endangered species be protected, but several commercial species would also be afforded a greater opportunity to reproduce without being disturbed. This additional protection would enhance mussel recruitment that could help replenish populations adjacent to the protected zones through dispersion of juvenile mussels by their fish hosts.



3. Consider closing the Cumberland River to commercial mussel harvesting due to the low recruitment rate of the upper reservoirs (Old Hickory and Cordell Hull) and lack of viability of the fishery in the lower reservoirs (Barkley and Cheatham). The Cumberland River reservoirs have not produced significant shell harvests during the last five years (combined average of 0.69% of annual harvest weight). Water quality and flow alterations resulting from emergency repair operations to Wolf Creek Dam are scheduled to continue for the next six years. The warmer temperatures predicted for this period may negatively affect Barkley Reservoir mussel populations, but could allow for increased recruitment in the upper reservoirs that could enhance the future commercial shellfishery. Closing the commercial mussel harvest on the Cumberland River would afford the population the opportunity for expansion and create the possibility of a rejuvenated fishery in the future.
4. Continue to monitor the mussel resource through commercial industry, population surveys, and laboratory analysis. These surveys provide critical trend data on the species composition, condition, volume of the mussel harvest, and population status.

### LITERATURE CITED

- Broadbent, T. 2007. Personal communication. Tennessee Wildlife Resources Agency, Region I Fisheries. Jackson, Tennessee.
- Couch, F. 2004. Personal communication. Tennessee Wildlife Resources Agency, Law Enforcement Division. Nashville, Tennessee.
- Clouse, G. 2009. 2008 Mussel harvest summary by lake. Tennessee Wildlife Resources Agency, Data Management Division. Nashville, Tennessee.
- Garner, J. 1991. Personal communication. Aquatic Resources Center. P.O. Box 680818, Franklin, Tennessee 37068-0818.
- Hubbs, D. 2008a. 2007 Statewide commercial mussel report. Tennessee Wildlife Resources Agency, Fish Management, Nashville, Tennessee. Report Number 08-09. 36pp.
- \_\_\_\_\_. 2008. Brood stock collection of *Plethobasus cooperianus* (orangefoot pimpleback mussel) and *Lampsilis abrupta* (pink mucket) from the Tennessee River downstream of Pickwick Landing Dam. Tennessee Wildlife Resources Agency, Endangered Species, Nashville, Tennessee.
- Loupe Online. Volume 17-Issue 2-Spring 2008. Gemological Institute of America. <http://www.gia.edu/loupeonline>.

Olson, D.W. 2007. 2006 Annual Review Mineral Industry Surveys, Gemstones. United States Geological Survey, 983 National Center, Reston, VA 20192.

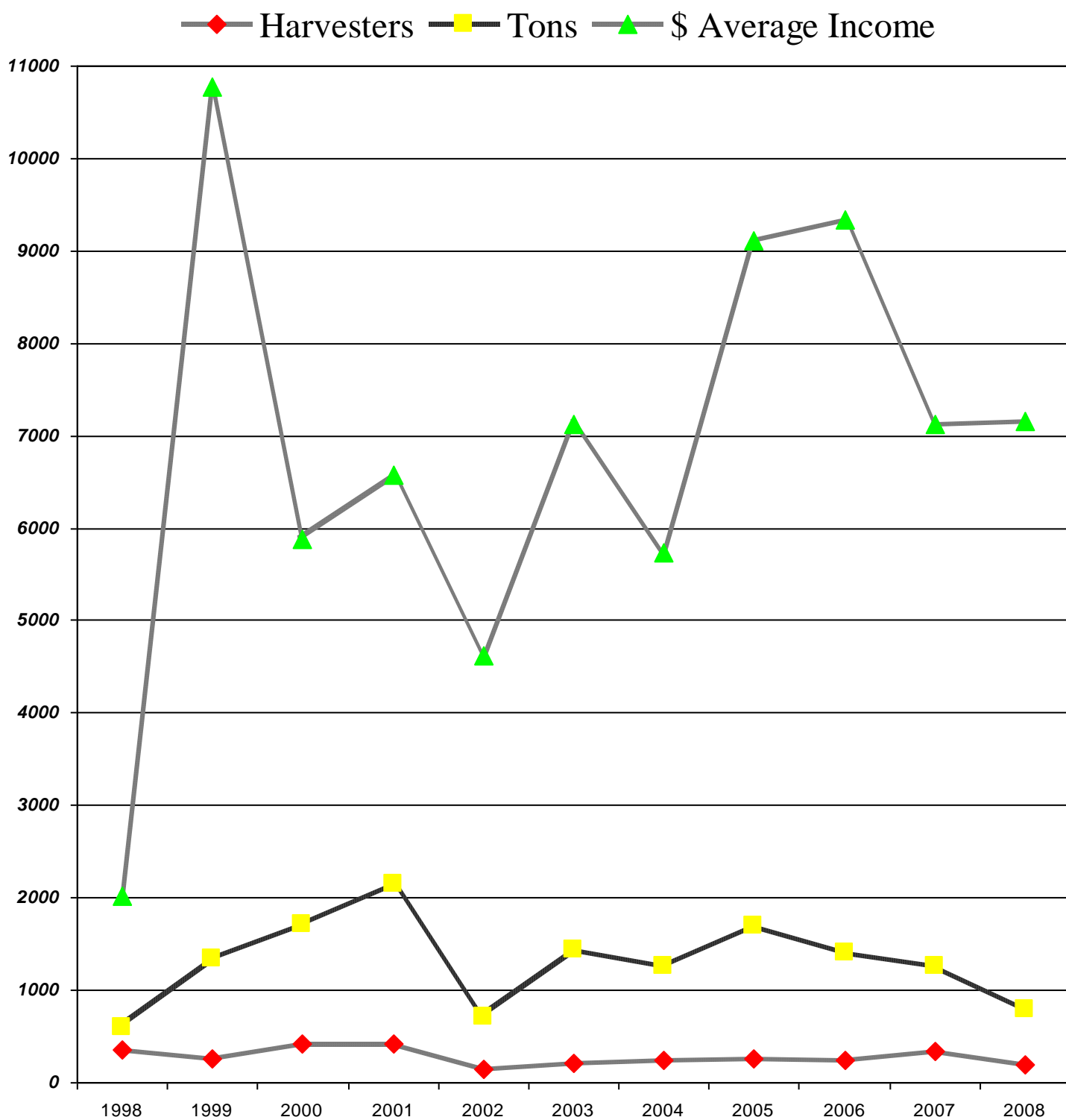
Parmalee, P.W. and A. E. Bogan. 1998. The Freshwater Mussels of Tennessee. The University of Tennessee Press/Knoxville. 328p.

PEARL OYSTER information bulletin. November 2008. Issue 18 - Secretariat of the Pacific Community <http://www.spc.int/Coastfish/News/POIB/POIB.htm>.

PEARL OYSTER information bulletin. November 2006. Issue 17 - Secretariat of the Pacific Community <http://www.spc.int/Coastfish/News/POIB/POIB.htm>.

Strayer, D. L. and D. R. Smith. 2003. A guide to sampling freshwater mussel populations. American Fisheries Society Monograph 8, American Fisheries Society, Bethesda, Maryland. 103 pages.

## **FIGURES**



**Figure 1. Tennessee mussel shell harvest trends, 1998 - 2008.**

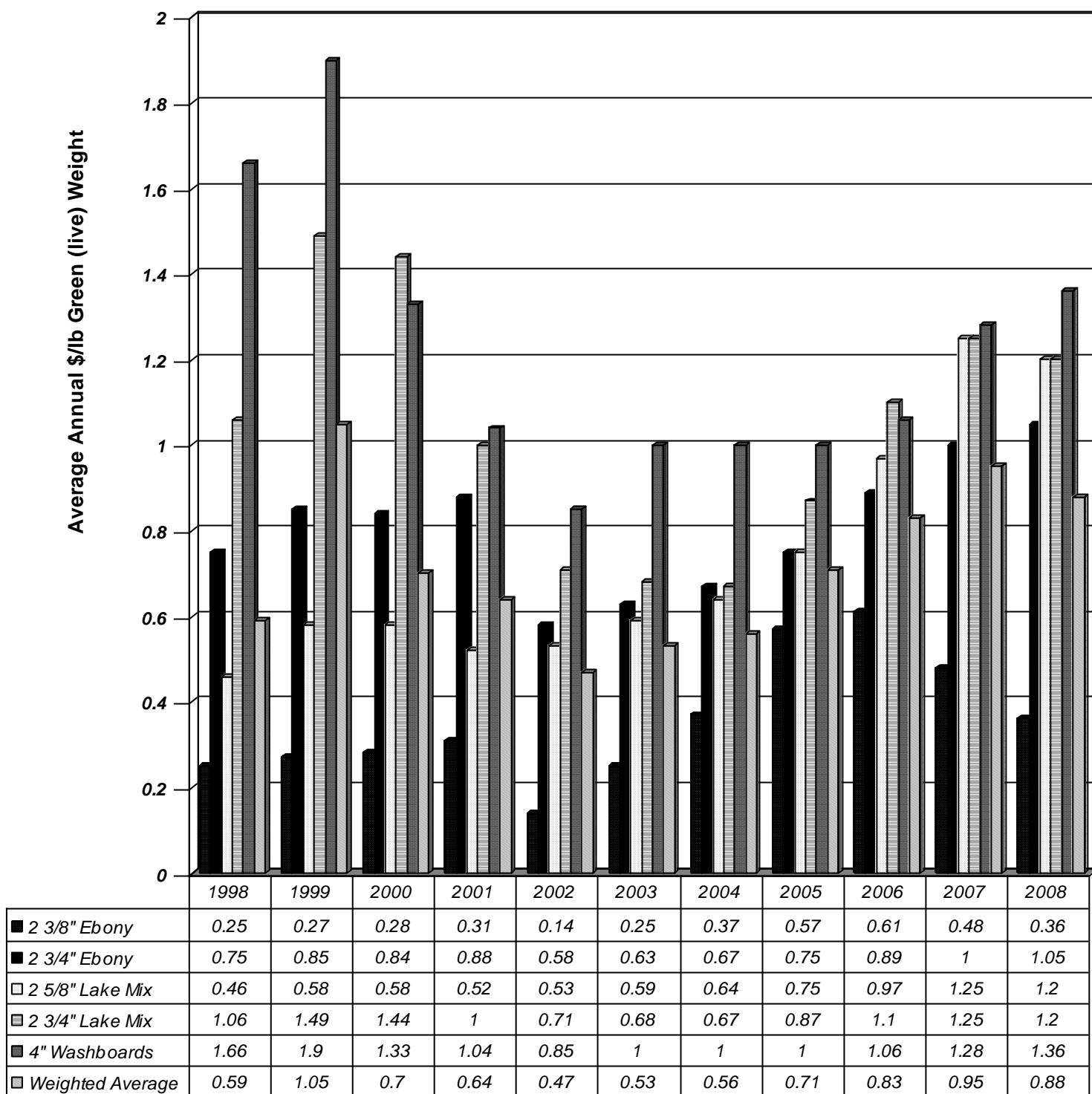


Figure 2. Tennessee wholesale shell price trends, 1998 - 2008.

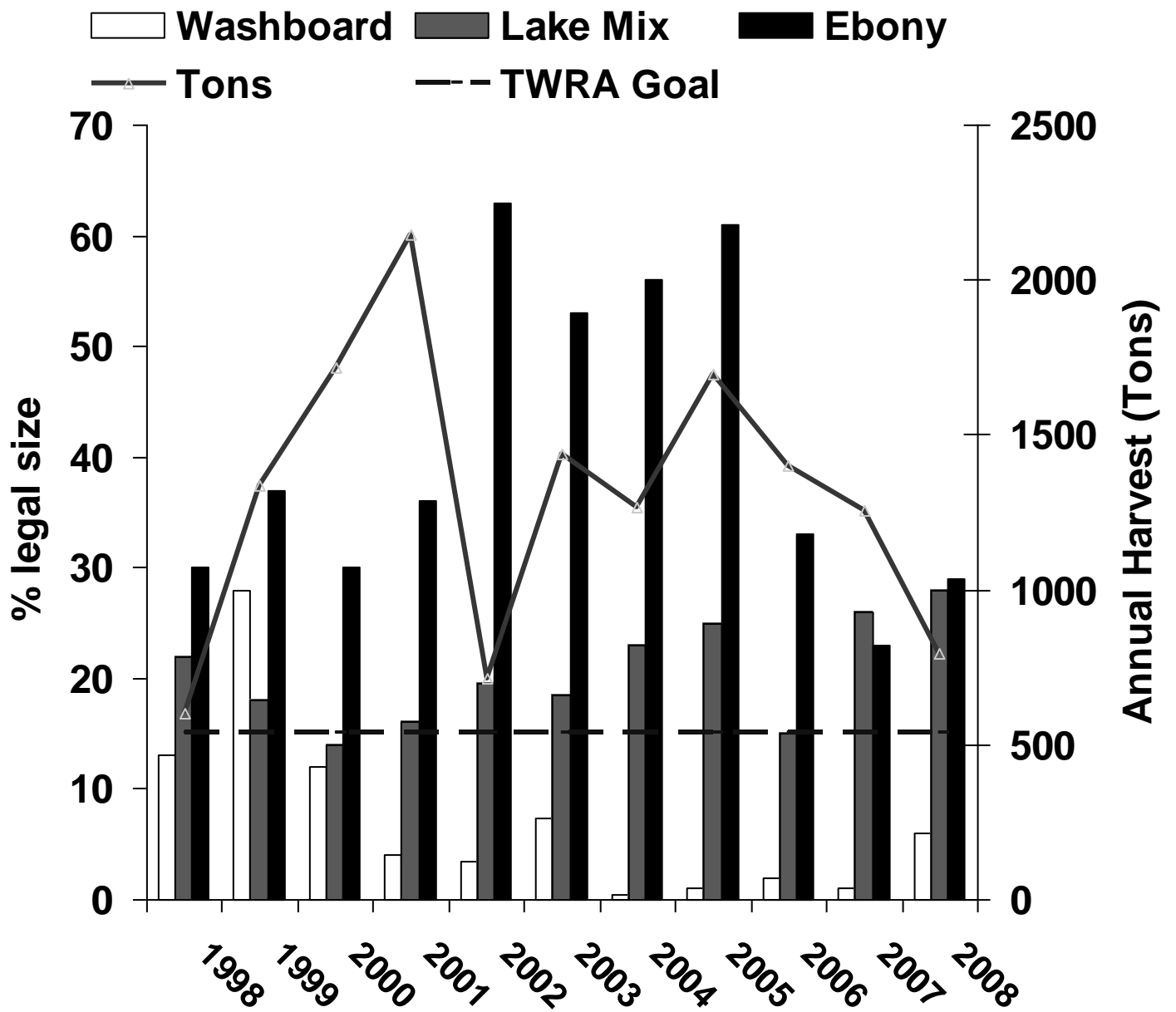
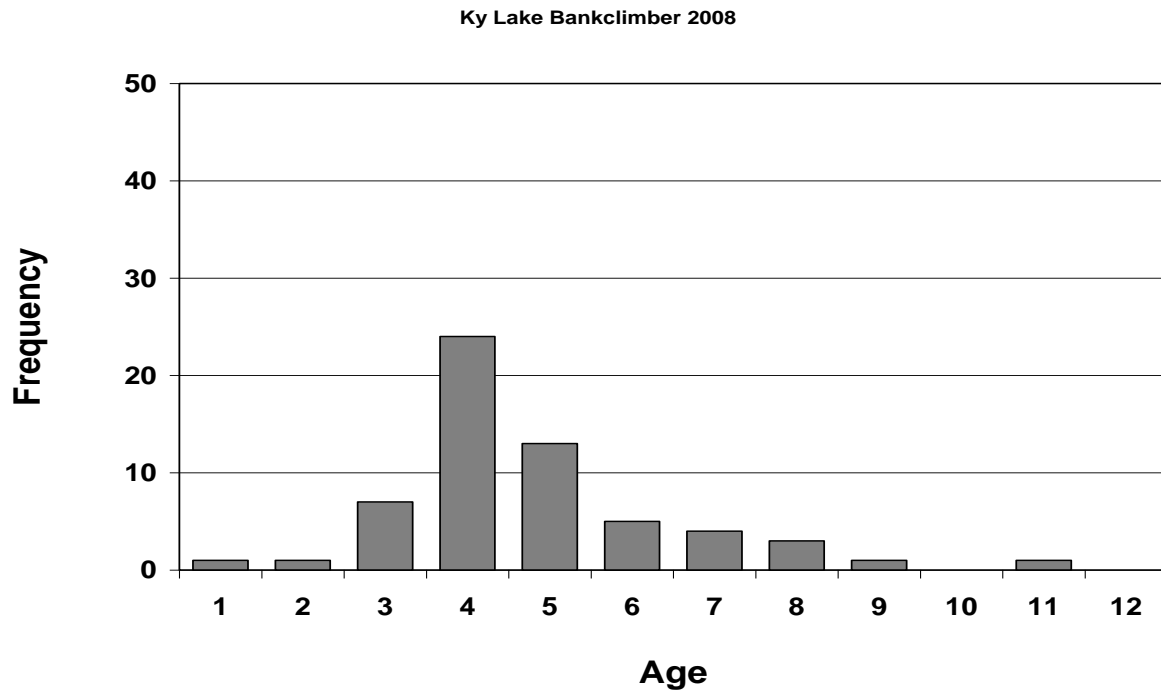
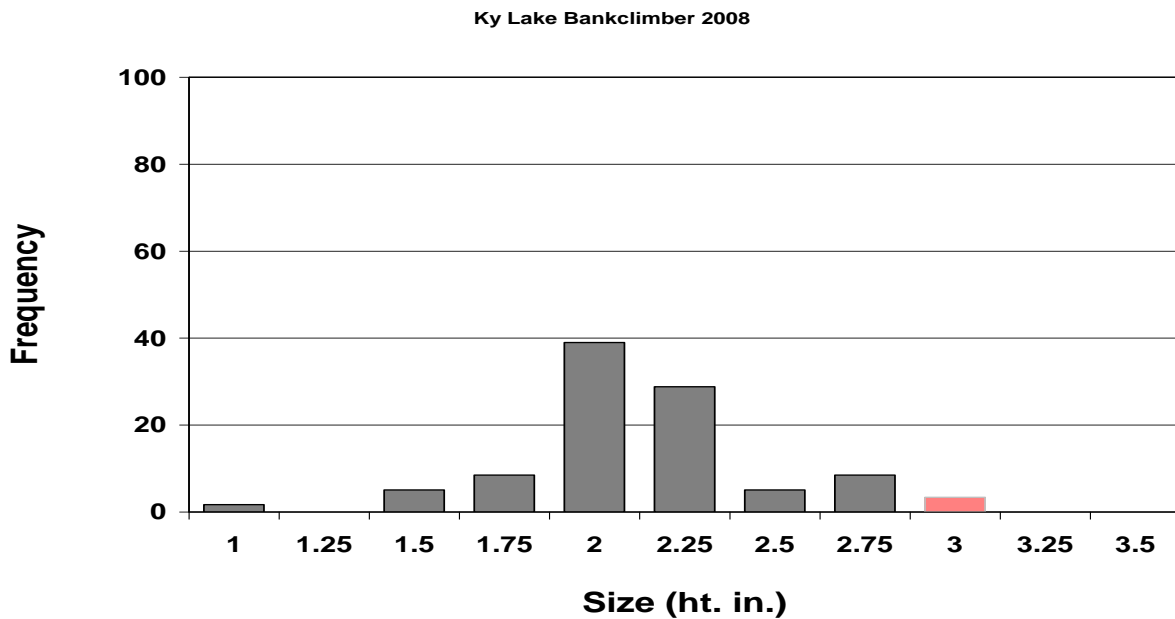


Figure 3. Legal sized mussel shell in Kentucky Reservoir population, 1998 - 2008.

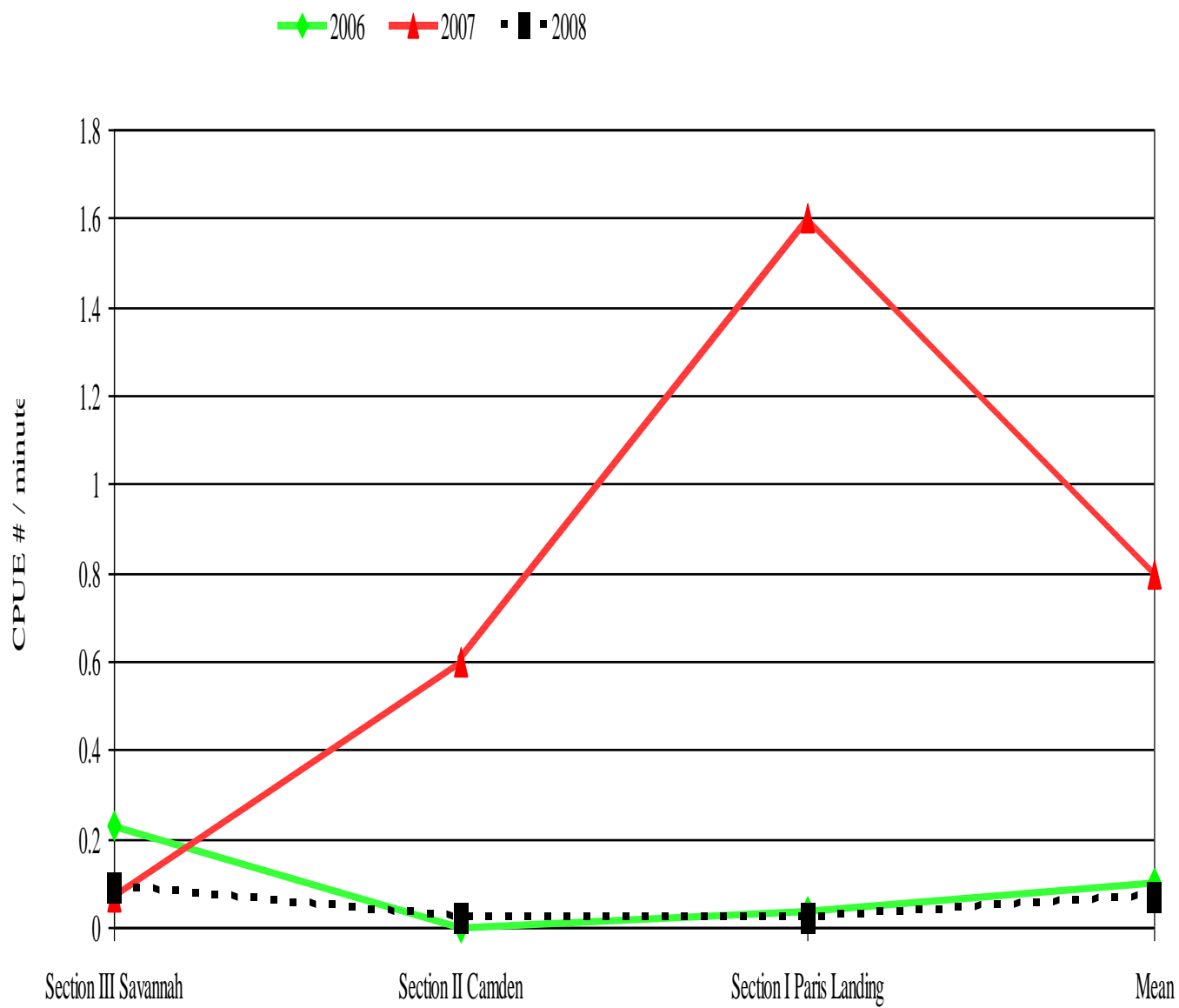


**Figure 4. Year class strength of bankclimbers collected from Kentucky Reservoir Section I, N = 60.**

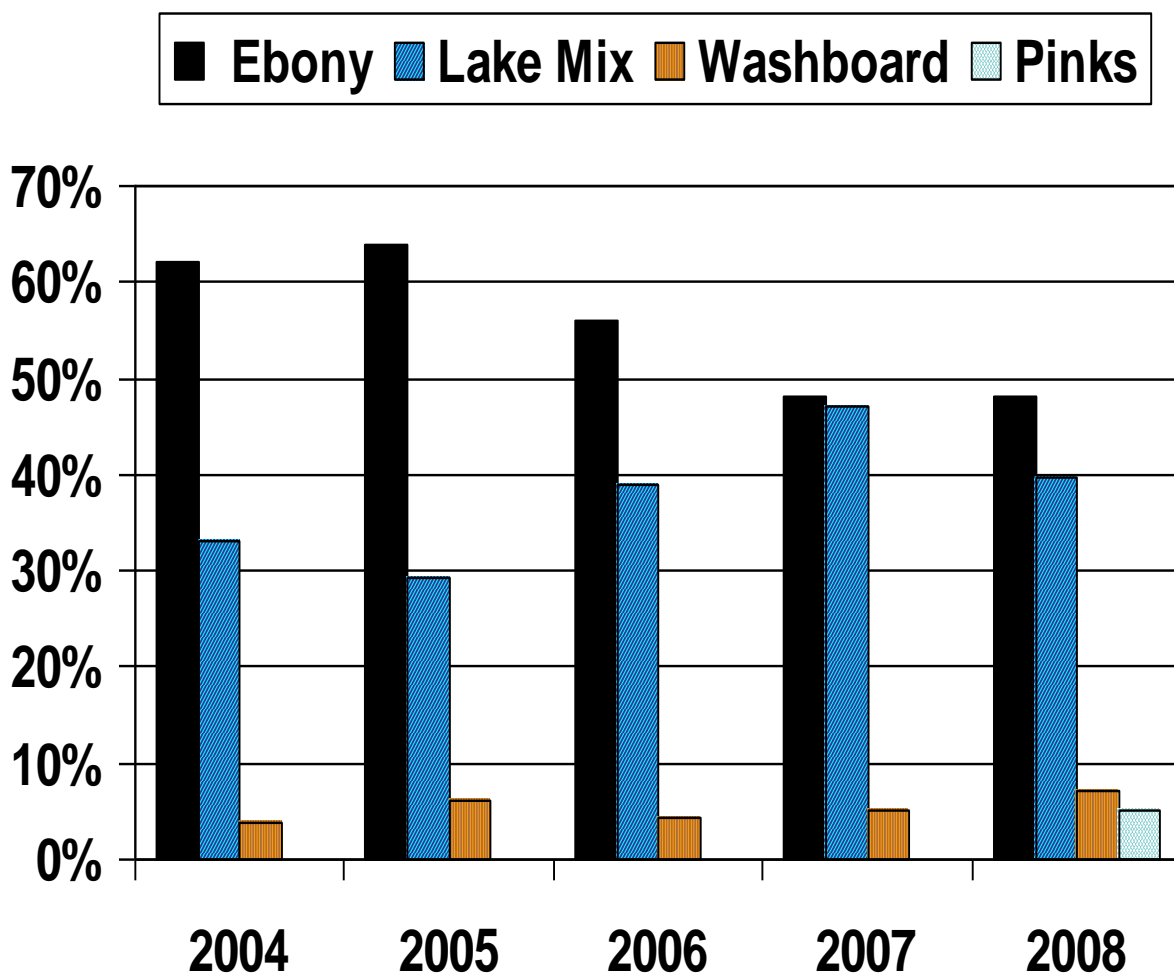


**Figure 5. Size class strength of bankclimbers collected from Kentucky Reservoir Section I, N = 60.**

# Commercial Site Assessments







**Figure 7. Annual Shell Harvest Weight Distribution by Species Group (TWRA Receipt Data).**

## **TABLES**

**Table 1. Harvest volume, value, license and shell fee revenue, 1992-2008.**

<b>Year</b>	<b>Tons of Mussels</b>	<b>Pounds of Mussels</b>	<b>Wholesale Value</b>	<b>License Revenue FY</b>	<b>Shell Fee CY</b>	<b>Total Revenue</b>	<b>Revenue % of Wholesale Value</b>
1992	2,258	4,516,416	\$4,613,120	\$75,330	\$56,533	\$131,863	2.86%
1993	1,643	3,286,373	\$4,572,810	\$113,165	\$41,382	\$154,547	3.38%
1994	2,707	5,414,238	\$8,492,090	\$135,850	\$67,773	\$203,623	2.40%
1995	3,881	7,761,235	\$14,731,777	\$223,625	\$103,666	\$327,291	2.22%
1996	2,362	4,723,088	\$6,820,139	\$189,195	\$65,731	\$254,926	3.74%
1997	1,061	2,121,907	\$3,024,779	\$101,875	\$33,140	\$135,015	4.46%
1998	601	1,201,514	\$709,133	\$57,000	\$15,185	\$72,185	10.18%
1999	1,335	2,669,716	\$2,800,239	\$39,125	\$38,187	\$77,312	2.76%
2000	1,717	3,434,087	\$2,412,133	\$71,875	\$50,946	\$122,821	5.09%
2001	2,144	4,287,072	\$2,734,081	\$62,625	\$53,625	\$116,250	4.25%
2002	714	1,429,293	\$665,326	\$25,625	\$15,759	\$41,384	6.22%
2003	1,439	2,878,808	\$1,531,327	\$33,375	\$35,049	\$68,424	4.47%
2004	1,267	2,533,947	\$1,417,753	\$48,375	\$31,786	\$80,161	5.65%
2005	1,693	3,386,254	\$2,404,375	\$69,500	\$32,985	\$102,485	4.26%
2006	1,400	2,800,901	\$2,336,027	\$60,900	\$31,174	\$92,074	3.94%
2007	1,253	2,505,205	\$2,378,398	\$96,900	\$33,924	\$130,824	5.50%
2008	792	1,583,626	\$1,387,187	\$79,500	\$26,210	\$105,710	7.62%
<b>TOTAL</b>	<b>28,267</b>	<b>56,533,680</b>	<b>\$63,030,694</b>	<b>\$1,483,840</b>	<b>733,055</b>	<b>\$2,216,895</b>	
<b>Average</b>	<b>1,663</b>	<b>3,325,511</b>	<b>\$3,707,688</b>	<b>\$87,771</b>	<b>\$43,121</b>	<b>\$131,949</b>	<b>3.52%</b>

FY = fiscal year

CY = calander year

**Table 2. Average wholesale price paid for various categories of commercial shell during 2008.**

<b>CATEGORY</b>	<b>CONDITION</b>	<b>AVERAGE PRICE (\$/LB)</b>	<b>SPECIES</b>
<b>LAKE MIX 2 5/8"</b>	<b>GREEN</b>	<b>\$1.20</b>	<i>A. plicata</i> , <i>F. flava</i> , <i>Q. quadrula</i> <i>Q. apiculata</i>
<b>LAKE MIX 2 3/4"</b>	<b>GREEN</b>	<b>\$1.20</b>	<i>A. plicata</i> , <i>F. flava</i> , <i>Q. quadrula</i> <i>Q. apiculata</i>
<b>ELEPHANT EAR</b>	<b>GREEN</b>	<b>\$0.50</b>	<i>E. crassidens</i>
<b>EBONY 2 3/8"</b>	<b>GREEN</b>	<b>\$0.36</b>	<i>F. ebena</i>
<b>EBONY 2 1/2"</b>	<b>GREEN</b>	<b>\$0.36</b>	<i>F. ebena</i>
<b>EBONY 2 5/8"</b>	<b>GREEN</b>	<b>\$0.99</b>	<i>F. ebena</i>
<b>EBONY 2 3/4"</b>	<b>GREEN</b>	<b>\$1.05</b>	<i>F. ebena</i>
<b>LAKE WASHBOARD 4.0"</b>	<b>GREEN</b>	<b>\$1.36</b>	<i>M. nervosa</i>
<b>LAKE WASHBOARD 5.0"</b>	<b>GREEN</b>	<b>\$1.36</b>	<i>M. nervosa</i>
<b>RIVER WASHBOARD 4.0" &amp; Larger</b>	<b>GREEN</b>	<b>\$1.28</b>	<i>M. nervosa</i>
<b>PINK HEELSPLITTER 4.0" &amp; Larger, Grade #1</b>	<b>OPEN</b>	<b>\$0.80</b>	<i>P. alatus</i>

**GREEN = Shell with meat**

**OPEN = Shell without meat**

**Table 3. 2008 wholesale commercial shell harvest by size category, as estimated from Tennessee waters.**

	<b>WEIGHT LBS</b>	<b>PERCENT WEIGHT</b>	<b>ESTIMATED VALUE</b>	<b>PERCENT VALUE</b>
<b>CATEGORY</b>				
<b>Lake Grade Washboards 4.0" to 4.5"</b>	<b>111,642</b>	<b>7.05%</b>	<b>\$151,833</b>	<b>10.95%</b>
<b>Lake Grade Washboards 5.0"</b>	<b>3</b>	<b>0.00%</b>	<b>\$4</b>	<b>0.0%</b>
<b>River Grade Washboards ≥4.0"</b>	<b>502</b>	<b>0.03%</b>	<b>\$643</b>	<b>0.05%</b>
<b>Pink Heelsplitter ≥4.0"</b>	<b>2,849</b>	<b>0.18%</b>	<b>\$2,279</b>	<b>0.16%</b>
<b>Ebony 2 3/8"</b>	<b>366,215</b>	<b>23.13%</b>	<b>\$131,837</b>	<b>9.50%</b>
<b>Ebony 2 1/2"</b>	<b>137,390</b>	<b>8.68%</b>	<b>\$49,460</b>	<b>3.57%</b>
<b>Ebony 2 5/8"</b>	<b>228,569</b>	<b>14.43%</b>	<b>\$226,283</b>	<b>16.31%</b>
<b>Ebony ≥2 3/4"</b>	<b>28,970</b>	<b>1.83%</b>	<b>\$30,419</b>	<b>2.19%</b>
<b>Lake Mix 2 5/8"</b>	<b>437,759</b>	<b>27.64%</b>	<b>\$525,311</b>	<b>37.87%</b>
<b>Lake Mix ≥ 2 3/4"</b>	<b>191,791</b>	<b>12.11%</b>	<b>\$230,149</b>	<b>16.59%</b>
<b>Total</b>	<b>1,583,626</b>	<b>100%</b>	<b>\$1,387,187</b>	<b>100%</b>
<b>Tons</b>	<b>792</b>			

**Table 4. Tennessee commercial mussel shell industry volume and value, 2004-2008.**

<b>Year</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>
<b>Harvesters</b>	<b>247</b>	<b>264</b>	<b>250</b>	<b>334</b>	<b>194</b>
<b>Dealers</b>	<b>14</b>	<b>15</b>	<b>15</b>	<b>15</b>	<b>13</b>
<b>Tons</b>	<b>1,267</b>	<b>1,693</b>	<b>1,400</b>	<b>1,253</b>	<b>792</b>
<b>Millions \$</b>	<b>\$1.4</b>	<b>\$2.4</b>	<b>\$2.33</b>	<b>\$2.38</b>	<b>\$1.3</b>
<b>Shell Fee</b>	<b>\$31,786</b>	<b>\$32,985</b>	<b>\$31,174</b>	<b>\$33,924</b>	<b>\$26,210</b>
<b>Average Wholesale price/lb</b>	<b>\$0.56</b>	<b>\$0.71</b>	<b>\$0.83</b>	<b>\$0.95</b>	<b>\$0.88</b>

**Table 5. Tennessee's commercial mussel shell harvest size class distribution by weight, 2004-2008.**

	<b>YEAR</b>				
<b>SIZE CLASS</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>
<b>2 3/8"</b>	<b>17.1%</b>	<b>21.1%</b>	<b>18.4%</b>	<b>23.5%</b>	<b>23.1%</b>
<b>2 1/2"</b>	<b>24.1%</b>	<b>21.2%</b>	<b>22.6%</b>	<b>9.3%</b>	<b>8.7%</b>
<b>2 5/8"</b>	<b>27.6%</b>	<b>32.4%</b>	<b>27.4%</b>	<b>41.5%</b>	<b>47%</b>
<b>2 3/4"</b>	<b>26.1%</b>	<b>18.4%</b>	<b>26.7%</b>	<b>20.7%</b>	<b>13.9</b>
<b>=&gt;4"</b>	<b>5.0%</b>	<b>6.8%</b>	<b>4.9%</b>	<b>5.0%</b>	<b>7.3</b>

**Table 6. Summary of commercial mussel species data, Kentucky Reservoir sections I, II, and III.**

<b>Section I - Paris Landing</b>	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
<i>Amblema plicata</i>	113	181	294	38%	34%
<i>Elliptio crassidens</i>		1	1	0%	0%
<i>Fusconaia ebena</i>	169	113	282	60%	32%
<i>Fusconaia flava</i>	7	30	37	19%	4%
<i>Megaloniaias nervosa</i>		99	99	0%	11%
<i>Potamilus alatus</i>	27	7	34	79%	4%
<i>Pleurobema cordatum</i>			0		
<i>Quadrula quadrula</i>	3	18	21	14%	2%
<i>Quadrula apiculata</i>	8	99	107	7%	12%
<i>Quadrula metanevra</i>		1	1	0%	0%
<b>Sites Sampled</b>			4		
<b>CPUE = mussels per minute</b>	1.64	2.75	4.38		
<b>Total</b>	327	549	876	37%	100%
<i>Plectomerus dombeyanus</i>			60		
<b>CPUE = <i>P. dombeyanus</i> / hour</b>			18.00		
<i>Dreissena polymorpha</i>			3		
<b>CPUE <i>D. polymorpha</i> / minute</b>			0.02		

<b>Section II - Camden</b>	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
<i>Amblema plicata</i>	55	82	137	40%	9%
<i>Elliptio crassidens</i>	2	5	7	0%	0%
<i>Fusconaia ebena</i>	421	634	1055	40%	66%
<i>Fusconaia flava</i>	6	34	40	15%	3%
<i>Megaloniaias nervosa</i>	18	170	188	10%	12%
<i>Potamilus alatus</i>	35	45	80	44%	5%
<i>Pleurobema cordatum</i>			0		
<i>Quadrula quadrula</i>			0		
<i>Quadrula apiculata</i>	8	71	79	10%	5%
<i>Quadrula metanevra</i>	1	3	4	25%	0%
<b>Sites Sampled</b>			4		
<b>CPUE = mussels per minute</b>	2.73	5.22	7.95		
<b>Total</b>	546	1044	1590	34%	100%
<i>Plectomerus dombeyanus</i>			1		
<b>CPUE = <i>P. dombeyanus</i> / hour</b>			0.30		
<i>Dreissena polymorpha</i>			3		
<b>CPUE <i>D. polymorpha</i> / minute</b>			0.02		



**Table 6. cont. Section III -  
Savannah**

	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
Amblema plicata	0	5	5	0%	0%
Elliptio crassidens	7	77	84	8%	7%
Fusconaia ebena	93	891	984	9%	77%
Fusconaia flava					
Megaloniaias nervosa		10	10	0%	1%
Potamilus alatus		3	3	0%	0%
Pleurobema cordatum	10	12	22	45%	2%
Quadrula quadrula		1	1	0%	0%
Quadrula apiculata		6	6	0%	0%
Quadrula metanevra	13	142	155	8%	12%
<b>Sites Sampled</b>			3		
<b>CPUE = mussels per minute</b>	0.82	7.65	8.47		
<b>Total</b>	123	1147	1270	10%	100%
<i>Lampsilis abrupta*</i>			14		
<b>CPUE <i>L. abrupta</i> / hour</b>			5.6		
<i>Dreissena polymorpha</i>			13		
<b>CPUE <i>D. polymorpha</i> / minute</b>			0.09		

**\* Federal Endangered Species**

<b>Section I, II, &amp; III combined</b>	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
Amblema plicata	168	268	436	39%	12%
Elliptio crassidens	9	90	99	9%	3%
Fusconaia ebena	683	1638	2321	29%	62%
Fusconaia flava	13	64	77	17%	2%
Megaloniaias nervosa	18	279	297	6%	8%
Potamilus alatus	62	55	117	53%	3%
Pleurobema cordatum	10	12	22	45%	1%
Quadrula quadrula	3	19	22	14%	1%
Quadrula apiculata	16	176	192	8%	5%
Quadrula metanevra	14	146	160	9%	4%
<b>Sites Sampled</b>			11		
<b>CPUE = mussels per minute</b>	1.81	4.99	6.81		
<b>Total</b>	996	2747	3743	27%	100%
<i>Dreissena polymorpha</i>			16		
<b>CPUE <i>D. polymorpha</i> / minute</b>			0.07		

**Table 6. cont. Closed Mussel**

<b>Mgmt Area, Section II</b>	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
Amblema plicata	66	95	161	41%	22%
Elliptio crassidens		1	1	0%	0%
Fusconaia ebena	237	205	442	54%	62%
Fusconaia flava	9	14	23	39%	3%
Megaloniaias nervosa	11	11	22	50%	3%
Potamilus alatus	15	7	22	68%	3%
Pleurobema cordatum			0		
Quadrula quadrula		3	3	0%	0%
Quadrula apiculata	2	37	39	5%	5%
Quadrula metanevra	3	1	4	75%	1%
<b>Sites Sampled</b>			2		
<b>CPUE = mussels per minute</b>	3.43	3.74	7.17		
<b>Total</b>	343	374	717	48%	100%
<i>Plectomerus dombeyanus</i>			1		
<b>CPUE = P. dombeyanus / hour</b>			0.60		
<i>Dreissena polymorpha</i>			0		
<b>CPUE D. polymorpha / minute</b>			0		

**Section III - Sanctuary TRM**

**203**

	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
Amblema plicata	6	1	7	86%	4%
Elliptio crassidens	10		10	100%	6%
Fusconaia ebena	120	5	125	96%	77%
Fusconaia flava					
Megaloniaias nervosa	3		3	100%	2%
Potamilus alatus	4	2	6	67%	4%
Pleurobema cordatum					
Quadrula quadrula					
Quadrula apiculata	1		1	100%	1%
Quadrula metanevra	9	2	11	82%	7%
<b>Sites Sampled</b>			1		
<b>CPUE = mussels per minute</b>	3.06	0.20	3.26		
<b>Total</b>	153	10	163	94%	100%
<i>Lampsilis abrupta</i> *			2		
<b>CPUE L. abrupta / hour</b>			2.40		
<i>Dreissena polymorpha</i>			2		
<b>CPUE D. polymorpha / minute</b>			0.01		

**\* Federal Endangered Species**

**Table 6. cont. Section III -  
Sanctuary TRM 141.5**

	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
Amblema plicata	2	4	6	33%	1%
Elliptio crassidens	1	23	24	4%	3%
Fusconaia ebena	19	763	782	2%	93%
Fusconaia flava					
Megalonaias nervosa		17	17	0%	2%
Potamilus alatus					
Pleurobema cordatum	2	4	6	33%	1%
Quadrula quadrula					
Quadrula apiculata		3	3	0%	0%
Quadrula metanevra		6	6	0%	1%
<b>Sites Sampled</b>			1		
<b>CPUE = mussels per minute</b>	0.48	16.40	16.88		
<b>Total</b>	24	820	844	3%	100%
<i>Lampsilis abrupta</i> *			0		
<b>CPUE <i>L. abrupta</i> / hour</b>			0.00		
<i>Dreissena polymorpha</i>			3		
<b>CPUE <i>D. polymorpha</i> / minute</b>			0.02		

**\* Federal Endangered Species**

**Table 7. Kentucky Reservoir percentage legal-sized commercial mussels by category, 2008.**

	<b>TWRA Population Samples, Sections I, II and III combined</b>			
	<b>N</b>	<b>Open Waters Legal-Sized</b>	<b>N</b>	<b>Closed waters Legal-Sized</b>
<b>Ebony <math>\geq 2\ 3/8''</math></b>	<b>2321</b>	<b>29%</b>	<b>1349</b>	<b>28%</b>
<b>Lake Mix <math>\geq 2\ 5/8''</math></b>	<b>708</b>	<b>28%</b>	<b>243</b>	<b>33%</b>
<b>Washboards <math>\geq 4''</math></b>	<b>297</b>	<b>6%</b>	<b>42</b>	<b>33%</b>

**Table 8. Cumberland River Old Hickory Reservoir Rome Landing mussel sanctuary, 2008.**

**Lovell's Island back chute CRM 298, 06/16, 08/26, & 10/29/2008, 6.8 man-hours D.**

**Sims, D. Hubbs, et al.**

<b>Rome Landing Sanctuary</b>	<b>Gravid</b>	<b>Non-Commercial</b>	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
<i>Actinonaias ligamentina</i>		3			3		1%
<i>Cyclonaias tuberculata</i>		8			8		3%
<i>Elliptio crassidens</i>			3		3	100%	1%
<i>Ellipsaria lineolata</i>	Yes	5			5		2%
<i>Fusconaia subrotunda</i>		2			2		1%
<i>Fusconaia flava</i>	Yes		1	2	3	33%	1%
<b><i>Lampsilis abrupta</i> *</b>	Yes	23			23		8%
<i>Lasmigonia complanata</i>		1			1		0%
<i>Leptodea fragilis</i>		1			1		0%
<i>Ligumia recta</i>	Yes	1			1		0%
<i>Megalonaias nervosa</i>			57	8	65	88%	23%
<i>Potamilus alatus</i>			1		1	100%	0%
<i>Pleurobema cordatum</i>	Yes		52	9	61	85%	21%
<b><i>Pleurobema plenum</i> *</b>		2			2		1%
<i>Pleurobema rubrum</i>		1			1		0%
<i>Pleurobema sintoxia</i>		4			4		1%
<i>Ptychobranhus fasciolaris</i>		6			6		2%
<i>Quadrula pustulosa</i>		25			25		9%
<i>Quadrula metanevra</i>			68	3	71	96%	25%
<b>Species</b>		<b>19</b>					
<b>CPUE = mussels per minute</b>			0.44	0.05	0.70		
<b>Total</b>		<b>82</b>	<b>182</b>	<b>22</b>	<b>286</b>	<b>64%</b>	<b>100%</b>
<i>Dreissena polymorpha</i>		0					
<b>Water Temperature</b>		<b>June 72°F</b>		<b>August 67°F</b>			<b>October 55°F</b>
<b>* Federal Endangered Species</b>							

**Table 8. cont. Carter's Island CRM 305, 06/26 & 08/27/2008, 3.3 man-hours D. Sims, D. Hubbs et al.**

<b>Rome Landing Sanctuary</b>	<b>Gravid</b>	<b>Non-Commercial</b>	<b>Legal</b>	<b>Sub-Legal</b>	<b>Total</b>	<b>%Legal</b>	<b>%Abundance</b>
Actinonaias ligamentina		1			1		1%
Cyclonaias tuberculata					0		
Elliptio crassidens		1			1		1%
Ellipsaria lineolata	Yes				0		
Fusconaia subrotunda					0		
Fusconaia flava	Yes				0		
<b>Lampsilis abrupta *</b>	Yes	8			8		6%
Lasmigonia complanata		1			1		1%
Ligumia recta	Yes	1			1		1%
Megalonaias nervosa			83	4	87	95%	70%
Potamilus alatus					0		
Pleurobema cordatum	Yes		6		6	100%	5%
<b>Pleurobema plenum*</b>					0		
Pleurobema rubrum					0		
Pleurobema sintoxia					0		
Ptychobranhus fasciolaris		2			2		2%
Quadrula pustulosa		11			11		9%
Quadrula metanevra			7		7	100%	6%
<b>Species</b>		<b>10</b>			10		
<b>CPUE = mussels per minute</b>			0.48	0.02	0.63		
<b>Total</b>		<b>25</b>	<b>96</b>	<b>4</b>	<b>125</b>	<b>77%</b>	<b>100%</b>
<i>Dreissena polymorpha</i>		0					
<b>Water Temperature</b>		<b>June 72°F</b>		<b>August 67°F</b>			<b>October 55°F</b>
<b>* Federal Endangered Species</b>							

## **APPENDICES**

**APPENDIX  
I  
2008 Wholesale Mussel Dealer  
& Receipt Report Summary Data**



Mussel  
Harvest by  
Lake

12/31/200  
8  
1/1/2008

Lake	shl	mea t	500	450	400	375	300	275	263	250	238	Total
BARKLEY RESERVOIR												
MEP	G		0	0	0	0	0	5484	0	0	0	5484
MLP	G		0	0	0	0	0	2150	0	0	0	2150
RMF	G		0	0	0	0	0	0	0	32	89	121
Total								7634		32	89	7755
FORT LOUDOUN RESERVOIR												
EES	G		0	0	0	0	0	0	46664	0	0	46664
LEB	G		0	0	0	0	0	0	0	0	20	20
LML	G		0	0	0	0	0	290	17	0	0	307
PHS	G		0	0	170	0	0	0	0	0	0	170
PHS	O		0	2	77	0	0	0	0	0	0	79
ZZZ	G		0	0	0	0	0	3053	19628	0	0	22681
Total				2	247			3343	66309		20	69921
KENTUCKY RESERVOIR												
DEB	G		0	0	0	0	0	0	0	110	184	294
EEB	G		0	0	0	0	0	0	12	0	0	12
EEP	G		0	0	0	0	0	0	7912	0	0	7912
EES	G		0	0	0	0	0	0	667	0	0	667
HLS	O		0	0	217	0	0	0	0	0	0	217
HSP	O		0	0	9	0	0	0	0	0	0	9
HSS	G		0	0	21	0	0	0	0	0	0	21
LEB			0	0	0	0	0	0	162	0	417	579
									21307	13622	33688	
LEB	G		0	0	23	0	5	28774	2	3	7	714984
LEB	O		0	0	0	0	0	0	414	0	14	428
LEG	G		0	0	0	0	0	0	86	0	50	136
LEW	G		0	0	0	0	0	0	20	0	0	20
LMF	G		0	0	0	0	0	0	0	0	1	1
LML			0	0	0	0	0	0	350	0	0	350
								18211	43408			
LML	G		0	0	185	0	262	8	5	745	299	617694
LML	O		0	0	0	0	0	74	244	0	0	318
LPT	G		0	0	0	0	0	0	296	0	0	296
LTR	G		0	0	0	0	0	1228	662	0	0	1890
LWB			0	0	44	0	0	0	0	0	0	44

				11094							
LWB	G	3	160	9	145	0	1	128	0	358	111744
LWB	O	0	0	283	0	0	0	0	0	0	283
LWG	G	0	0	10	0	0	0	0	0	0	10
MEP	G	0	0	0	0	0	0	2105	0	0	2105
PHS	G	0	0	376	0	0	0	0	0	0	376
PHS	O	0	0	1977	0	0	0	0	0	0	1977
RB	G	0	0	12	0	0	0	0	0	0	12
REB	G	0	0	1	0	0	100	9359	210	17451	27121
REB	O	0	0	0	0	0	0	48	70	2418	2536
RMF	G	0	0	0	0	0	66	1013	0	7934	9013
RML	G	0	0	0	0	0	0	205	0	0	205
RWB	G	0	0	482	8	0	0	0	0	0	490
ZZZ	G	0	0	0	0	0	0	401	0	93	494
ZZZ	O	0	0	0	0	0	0	3661	0	0	3661
				11458		21236		67490		13735	
Total		3	160	9	153	267	1	2	8	6	9
NICKAJACK RESERVOIR											
LWB	G	0	0	51	0	0	0	0	0	0	51
Total				51						51	

**APPENDIX  
II  
Freshwater Mussel Species  
Collected From Kentucky Reservoir  
During 2008 Sampling and Observations**

**2008 Mussel species collected from Kentucky Reservoir all sites and supplemental sampling, 1 = collected live.**

**Species**

1	<i>Anadonta suborbiculata</i>	1
2	<i>Pyganodon grandis</i>	1
3	<i>Utterbackei imbecillis</i>	1
4	<i>Amblema plicata</i>	1
5	<i>Arcidens confragosa</i>	1
6	<i>Cumberlandia monodonta</i>	
7	<i>Cyclonaias tuberculata</i>	1
8	<b><i>Cyprogenia stegaria</i>*</b>	1
9	<i>Elliptio crassidens</i>	1
10	<i>Ellipsaria lineolata</i>	1
11	<i>Fusconaia ebena</i>	1
12	<i>Fusconaia flava</i>	1
13	<b><i>Lampsilis abrupta</i>*</b>	1
14	<i>Lampsilis cardium</i>	
15	<i>Lampsilis ovata</i>	1
16	<i>Lampsilis teres</i>	1
17	<i>Lasmigonia complanata</i>	
18	<i>Leptodea fragilis</i>	1
19	<i>Ligumia recta</i>	1
20	<i>Megalonaias nervosa</i>	1
21	<i>Obliquaria reflexa</i>	1
22	<i>Plectomerus dombevanus</i>	1
23	<b><i>Plethobasus cooperianus</i>*</b>	1
24	<i>Plethobasus cyphus</i>	
25	<i>Pleurobema rubrum</i>	1
26	<i>Pleurobema cordatum</i>	1
27	<i>Pleurobema sintoxia</i>	
28	<i>Potamilus alatus</i>	1
29	<i>Potamilus ohiensis</i>	1
30	<i>Ouadrula apiculata</i>	1
31	<i>Ouadrula c. cylindrica</i>	1
32	<i>Ouadrula metanevra</i>	1
33	<i>Ouadrula nodulata</i>	1
34	<i>Ouadrula pustulosa</i>	1
35	<i>Ouadrula quadrula</i>	1
36	<i>Toxolasmus parvus</i>	1
37	<i>Toxolasmus lividus</i>	
38	<i>Truncilla donaciformis</i>	1
39	<i>Truncilla truncata</i>	1
40	<i>Tritogonia verrucosa</i>	1
	<b>TOTAL</b>	<b>34</b>
	<b>EXOTIC SPECIES</b>	
	<i>Dreissena polymorpha</i>	1
	<i>Corbicula fluminea</i>	1

**\*Federal Endangered species**

**APPENDIX  
III  
Zebra Mussel Distribution  
In Tennessee**



Since the first documented collection of the zebra mussel in Tennessee occurred on the Tennessee River at Savannah, Hardin Co., Tennessee during February 1992, reports of one to several individuals have become more numerous. Clusters of zebra mussels have been discovered on the lock walls of most TVA and Army Corps of Engineer facilities open to commercial navigation traffic on the Tennessee and Cumberland rivers. Barge and boat traffic are believed to be the primary vectors of dispersion of this exotic species. Summer water temperature extremes, fish predation and water chemistry characteristics may be limiting the expansion of the zebra mussel population in some areas, particularly the lower Tennessee River.

Zebra mussel sightings continue to be reported by commercial musselers working the Kentucky Reservoir portion of the Tennessee River system. While it has yet to develop densities that endanger the native mussel fauna, frequency of occurrence and number of individuals increased in 2007 at TWRA's annual commercial mussel assessment sites on Kentucky Reservoir to 0.8 individuals per minute. However, 2008 samples showed a decline to 0.02 individuals per minute.

Zebra mussel densities in the upper Tennessee River system increased during the late 1990's through 2001. An established colony of zebra mussels below Watts Bar Dam, at TRM527.1, increased from 600 to just over 5,000 per square meter in late 2001. At TRM558.2, zebra mussels reached an even higher density of 23,166 per square meter. A large population was also noted below Chickamauga Dam, at TRM 470.0. Density at this site was estimated at 11,613 per square meter (Tennessee Valley Authority, 2002). However, the hot and dry summers of 2004, 2005 and 2007 significantly limited these populations. Only two live zebra mussels were encountered at nine TWRA freshwater mussel assessment sites below Watts Bar Dam during sampling conducted in 2005, resulting in a CPUE of 0.45 zebra mussels per hour.

Zebra mussels have colonized the Mississippi River along the western border of Tennessee. They are abundant and attached to surfaces of concrete and rock bank stabilization structures below the water line. Some native mussels collected from the Mississippi River have been covered with zebra mussels.

TWRA personnel will continue to monitor zebra mussel populations through cooperation with commercial harvesters, and other government agencies. While accurately predicting what ultimate effect this exotic species will have on native mussel stocks and other aquatic species is difficult, the potential for devastation does exist. For more on zebra mussels and their current distribution in the United States go to [http://www.glsc.usgs.gov/\\_files/factsheets/2000-6%20Zebra%20Mussels.pdf](http://www.glsc.usgs.gov/_files/factsheets/2000-6%20Zebra%20Mussels.pdf).

**APPENDIX  
IV  
Commercial Mussel Program Funding Status  
2004 -2008**

<b>Commercial Mussel Program Statistics</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>TOTAL</b>	<b>Average</b>
Harvester Licenses	247	264	250	334	194	1289	258
Shell Dealers Licenses	14	15	15	15	13	72	14
Pounds Harvested	2,533,947	3,386,254	2,800,901	2,505,205	1,586,677	12,812,984	\$2,562,597
Wholesale Harvest Value	\$1,417,753	\$2,404,375	\$2,336,027	\$2,378,398	\$1,387,187	\$9,923,740	\$1,984,748
Shell Fee collected	\$31,786	\$32,985	\$31,174	\$33,924	\$33,494	\$163,363	\$32,673
Proposed Shell Fee @ \$0.10/lb	\$253,395	\$338,625	\$280,090	\$250,520	\$158,668	\$1,122,630	\$280,658
Proposed Shell Fee @ \$0.05/lb	\$126,697	\$169,313	\$140,045	\$125,260	\$79,334	\$561,315	\$140,329
License Revenue by Fiscal Year	\$48,375	\$47,725	\$32,126	\$78,500	\$79,500	\$286,226	\$57,245
Total Revenue	\$80,161	\$80,710	\$63,300	\$112,424	\$112,994	\$449,589	\$89,918
Mussel Program Expenditures Fiscal Year	\$229,654	\$275,324	\$277,046	\$259,037	\$237,974	\$1,279,035	\$255,807
Program Funding Balance	<b>-\$149,493</b>	<b>-\$194,614</b>	<b>-\$213,746</b>	<b>-\$146,613</b>	<b>-\$124,980</b>	<b>-\$829,446</b>	<b>-\$176,117</b>
Program Funding Balance @ \$0.10/lb	<b>\$103,902</b>	<b>\$144,011</b>	<b>\$66,344</b>	<b>\$103,908</b>	<b>\$33,688</b>	<b>\$360,497</b>	<b>\$104,541</b>
Program Funding Balance @ \$0.05/lb	<b>-\$22,796</b>	<b>-\$25,301</b>	<b>-\$73,701</b>	<b>-\$21,353</b>	<b>-\$45,646</b>	<b>-\$188,797</b>	<b>-\$35,788</b>